

RADIOACTIVITY LEVELS IN OHIO'S RESIDENT CANADA GOOSE (*BRANTA CANADENSIS*) POPULATIONS¹

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Abstract. Gross beta and ¹³⁷Cs radioactivity levels were determined for pectoralis muscle of resident Canada geese (*Branta canadensis*) in 3 wildlife areas in Ohio. The mean ¹³⁷Cs level was 0.9 dpm/g dry wt muscle (0.4 pCi/g), and the mean gross beta level was 20.4 dpm/g dry wt muscle (9.2 pCi/g). No differences in goose muscle radioactivity levels were observed among the 3 wildlife areas. Bird age apparently did not affect radioactivity level. Variance components between and within birds were computed and a sampling design, to optimize allocation of resources for future sampling schemes, was determined.

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Nuclear power plants, and related fuel reprocessing facilities, will probably become increasingly prevalent in the near future. The current release of radioactivity from these facilities into the environment, the potential for future release, and possible incorporation of this material into biota, is a major area of concern for biologists. In view of this fact, it is important that radioactivity levels in biotic populations be documented prior to plant operation. Variation in radioactivity levels due to biotic and/or abiotic environmental parameters should be determined prior to operation of nuclear electrical generating facilities in an area so that any increase in radioactivity levels due to these facilities can be determined accurately. Only by having knowledge of the amounts of natural radioactivity, and the manner in which it varies, can an intelligent interpretation of monitoring data be ensured (Eisenbud, 1973).

Very few data are available on radioactivity levels in waterfowl in Ohio except for Industrial BIO-TEST Laboratories (1973a, 1973b, 1975) preoperational environmental radiological monitoring for the Davis-Besse plant, Oak Harbor, Ohio. The Laboratories looked at a

number of waterfowl species, and their values for gross beta and ¹³⁷Cs are similar to those reported in the present study. The objectives of the present study were to determine ¹³⁷Cs and gross beta radioactivity levels in Ohio's resident Canada goose (*Branta canadensis*) populations prior to start-up of nuclear power plants in the state, and to determine sources of variation (and variance components) in those levels.

MATERIALS AND METHODS

A total of 18 birds were collected from Magee Marsh, Mosquito Creek, and Grand Lake St. Marys State wildlife areas from 14 June to 7 July, 1975. Geese ranged in age from 1 through 7 years as determined by banding data. No more than one bird per age class was collected from each area. Following collection, birds were killed by cervical dislocation and placed in a deep freeze.

In preparation for radioassay, birds were thawed and breast muscle (pectoralis major) 5×8 cm samples were excised and dried at 100°C for 24 hours prior to radioassay. The air-dried samples were allowed to cool overnight in a glass desiccator. Samples were then finely ground with mortar and pestel, and placed in tightly capped glass vials until analyzed.

For gross beta determinations, 0.3-0.4 g samples of finely ground muscle were placed in aluminum planchets approximately 3 cm diameter and radioassay was performed with a thin-window, gas-flow GM detector. A total of 10,000 counts were collected per sample with the total count time per sample approximately 600 minutes. Background levels were determined prior to counting each series and 5 replicate counts were done for each bird.

Radioassay for ¹³⁷Cs was done with a 7.6 cm² NaI thallium activated scintillation crystal

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and multichannel analyzer. The detector was housed in a 90 cm³ lead shield with 10 cm thick walls. Samples of approximately 10 g were placed in 5 cm plastic petri dishes and the dishes were placed in contact with the flat face of the cylindrical detector (2 π geometry). Samples were counted for 800 minutes each. Four replicates were taken from each bird and background determinations were made before and after radioassay of each bird.

Computer analysis of the data was carried out through the Statistical Analysis System (Service, 1972). A nested analysis of variance was performed on the data, which consisted of replicates within bird and birds within area. Because only one bird was collected per age class from each area, birds could not be nested within age. In order to look at age as a possible explanation of the variability between birds, linear regressions were fitted to the data from each area.

The method of optimal allocation of resources used in the present study was taken from Sokal and Rohlf (1969) as shown below:

$$(1) \quad S^2Y = \frac{s^2}{nb} + \frac{s^2B}{b}$$

Where:

S^2Y = estimated variance per bird

s^2B = estimated variance component between birds with variance within birds accounted for

s^2 = estimated variance component within birds

b = number of birds

n = number of replicates per bird

For determining the optimal number of replicates per bird the following equation was used:

$$(2) \quad n = \sqrt{\frac{C_B \cdot s^2}{C_{R/B} \cdot s^2B}}$$

Where:

C_B = cost per bird (appx. \$20)

$C_{R/B}$ = cost of replicate within bird (appx. \$5)

RESULTS AND DISCUSSION

The mean gross beta level in birds from Magee Marsh was 21.5 disintegrations per minute per gram dry weight of muscle (dpm/g), at Mosquito Creek 20.1 dpm/g and at Lake St. Marys 19.7 dpm/g. The mean ¹³⁷Cs level in birds from Magee Marsh was 0.8 dpm/g, at Mosquito Creek 1.1 dpm/g and at Lake St. Marys 0.7 dpm/g (table 1). No differences in radioactivity levels of goose muscle were observed among ages or areas, so variability reduced to that between birds, and that within birds. Throughout the rest of the paper, variation between birds

is expressed as variation left after variation within birds has been accounted for.

The mean gross beta concentration for all birds was 20.4 dpm/g (table 1). Since 2.22 dpm equals 1 picocurie (pCi), this value is equivalent to 9.2 pCi/g. Approximately 26% of the variation encountered was attributed to within birds and about 74% between birds. Variation in these birds was 0.9 dpm/g ($P < 0.01$).

Table 1 shows the final analysis of the ¹³⁷Cs data. The mean ¹³⁷Cs concentration in these birds was 0.9 dpm/g or (0.4 pCi/g). Approximately 73% of the variation encountered was attributed to within birds and about 27% between

TABLE 1

Gross beta and ¹³⁷Cs radioactivity levels in Ohio Canada geese collected 14 June to 7 July, 1975.

Goose Age	Radioactivity level (dpm/g dry wt)	
	Gross beta	¹³⁷ Cs
MAGEE MARSH		
5	25.9±0.5 ^a	1.0±0.7 ^b
6	21.5±1.6	0.8±0.8
2	20.1±1.8	1.1±0.5
4	21.0±1.4	0.6±0.1
3	18.6±1.5	0.7±0.6
7	21.9±0.7	0.7±0.6
\bar{X}	21.5±1.3	0.8±0.6
LAKE ST. MARYS		
2	23.5±2.3	1.1±0.3
1	18.1±1.5	0.9±0.7
7	18.2±0.6	0.9±0.7
4	19.3±1.0	1.1±0.7
5	18.2±1.5	0.2±0.5
6	19.2±0.7	0.2±0.1
3	21.1±0.6	0.7±0.8
\bar{X}	19.7±1.2	0.7±0.5
MOSQUITO CREEK		
4	23.5±2.1	1.9±0.8
1	22.1±1.6	1.7±0.3
2	17.0±2.6	0.9±0.6
3	15.6±1.9	0.6±0.4
5	22.2±1.2	0.3±0.1
\bar{X}	20.1±1.9	1.1±0.4
Mean of all geese		
20.4±1.5		0.9±0.6

^aMean ± standard deviation of 5 replicate determinations for each goose.

^bMean ± standard deviation of 4 replicate determinations for each goose.

birds. Variation between birds was significant ($P < 0.01$).

In studies similar to the present one it is generally desirable to optimize allocation of resources. This involves determining the optimal number of replicates per bird and the optimal number of birds to be sampled. The variance components in equation (1) can be utilized for the purpose of determining the optimal number of replicates per bird. The calculated variance components for the present study are:

for gross beta: $s^2_B = 6.364$; $s^2 = 2.289$

for ^{137}Cs : $s^2_B = 0.118$; $s^2 = 0.312$

By substituting the calculated variance components and cost figures into equation (2) the optimal number of replicates per bird can be calculated. These figures are 3 for ^{137}Cs radioassay and 1 for gross beta radioassay.

The statistically significant natural variation between birds is important to document because it indicates that a number of birds must be sampled in order to obtain a valid documentation of radioactivity levels. The number of birds sampled is dependent upon the confidence level desired by the investigator and the amount of money available for the study.

The following analysis assumes a 10% variability level as being acceptable ($\pm 10\%$ of the mean). The total number of birds b [as defined in equation (1)] needed to meet this assumption can now be determined. The confidence interval (C.I.) for $\pm 10\%$ of the mean is:

$$(3) \quad \text{C.I.} = 0.1\bar{x} = t\sqrt{S^2_Y}$$

Rearranging (3) yields

$$(4) \quad S^2_Y = \left(\frac{0.1\bar{x}}{t} \right)^2$$

The variance components and means

given in table 1 (20.4 dpm for beta and 0.9 dpm for ^{137}Cs) were substituted into equations (1) and (4). The t value for (4) was obtained from Student's t -distribution (Sokal and Rohlf, 1969). Setting (1) equal to (4) and solving for b yielded $b = 115$ for the ^{137}Cs radioassay and $b = 11$ for the gross beta radioassay. This indicates that for an acceptable variability level of 10%, I under-sampled for ^{137}Cs and over-sampled for gross beta radioassay. The variance components presented in this paper can be used in other environmental monitoring programs to optimize the number of animals and tissue sampling design for gross beta and ^{137}Cs radioassay.

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